BEYOND THE RELATIONAL PRINCIPLE OF REINFORCEMENT[1]

James Allison

INDIANA UNIVERSITY

Behavior under baseline conditions in which the contingency is absent can shed some light on the individual's performance under a schedule, but is insufficient as a basis for prediction of performance. This insufficiency of the baseline data runs counter to a recent formalization of the relational principle of reinforcement (Donahoe, 1977). A more satisfactory predictive model must incorporate not only the baseline level of the instrumental response and that of the contingent response, but also the schedule requirements, the character of each response in relation to the other, and the behavior required in simply switching from each to the other.

Key words: reinforcement, Premack's principle, conservation, response deprivation, matching, facilitation, suppression

Donahoe (1977) formulated Premack's relational principle (Premack, 1965) as an equation, and derived from the equation several implications for choice behavior, interresponse-time distributions, and stimulus control. The present paper calls attention to evidence that contradicts Donahoe's equation, and which therefore calls into question the derivative implications as well. Some of the evidence has been reviewed before (Allison and Timberlake, 1973, 1974; Timberlake and Allison, 1974), but much is fairly recent, and its bearing on Premack's principle may have escaped general notice.

According to Donahoe (1977, Equation 2), the following equation is consistent with the Premack principle:

$$p'_N = p_N + k(p_C - p_N), \qquad (1)$$

where p'_N is the asymptotic probability of the "noncontingent" or instrumental response after the contingency has been instituted. Before the institution of the contingency, the responses have baseline or operant probabilities[2] denoted p_N in the case of the instrumental response, and p_C in the case of the contingent response. The sensitivity of the organism to the difference between p_C and p_N is represented by k, an empirical constant. Donahoe does not specify the permissible values of k, but it is clear from his account of the equation's implications that he supposes k to be positive.

Assuming that k is positive, the equation implies that the institution of the contingency will raise the instrumental response above its baseline probability—i.e., the contingency will "condition", "reinforce", or facilitate the instrumental response—if, and only if, the contingent response has a higher baseline probability than the instrumental response. In other words, the equation implies that $p'_N > p_N$ if, and only if, $p_C > p_N$. Similarly, the contingency theoretically will suppress the instrumental response if, and only if, the contingent response has the lower baseline probability: $p'_N < p_N$ if, and only if, $p_C < p_N$.

One piece of evidence that seems to contradict Equation 1 can be found in Premack's brief report of an experiment with rats, in which the instrumental response was running in an activity wheel and the contingent response, drinking, had the higher baseline probability. The contingency failed to facili-

[2]There are several definitions of baseline probabilities, no one of which is universally correct (Timberlake and Allison, 1974). The one that Premack espoused, which appears to be used most commonly, and which is used throughout this paper, is the paired operant baseline probability (Timberlake and Allison, 1974).

tate running, despite the fact that the experiment fulfilled the antecedent condition which, according to Equation 1, should have been sufficient for the facilitation of running (Premack, 1965, p. 171).

Premack suggested that the contingency might have failed to facilitate running because the contingency schedule did not satisfy another antecedent condition: in the terminology of Timberlake and Allison (1974), the schedule did not deprive the rat of the contingent drinking response. In other words, perhaps the contingency failed to facilitate running because the instrumental running requirement was so small, relative to the amount of contingent drinking allowed, that the rat could perform the baseline amount of drinking by performing only the baseline amount of running. Earlier experiments that succeeded in facilitating instrumental running had used schedules that deprived the rat of the contingent drinking response. That is, the instrumental running requirement in the earlier experiments was so large, relative to the amount of contingent drinking allowed, that if the rat had performed only the baseline amount of running, it would necessarily have performed less than the baseline of drinking.

Clearly, the antecedent condition of response deprivation depends partly on the baselines of the two responses, and partly on the exact contingency schedule requirements—e.g., how much running is required for each access to the drinking tube, and how much drinking is allowed when access is gained. Equation 1 by itself makes no reference to response deprivation as an antecedent condition; the baselines are represented as p_C and p_N, but the schedule requirements have no representation in the equation. Nevertheless, it is possible that Donahoe's intention is to restrict Equation 1 to schedules that deprive the individual of the contingent response. In his verbal statement of Premack's theoretical condition for facilitation, Donahoe refers to an instrumental response followed by a more probable contingent response, "if the organism has been deprived of the contingent response" (Donahoe, 1977, p. 341). It is not clear whether Donahoe means "deprived" in the specific technical sense defined by Timberlake and Allison (1974). If he does, then Equation 1 is not intended to apply to schedules that do not deprive the individual of the contingent response, and its adequacy cannot be judged in terms of the outcomes of such experiments as Premack's.

The literature now includes several experiments in which the contingency schedule did deprive the subject of the contingent response, with results still contradictory to Equation 1. Shettleworth (1975, Experiment 4) used schedules that deprived the hamster of contingent eating. Eating was paired as a contingent response with six different instrumental responses, each of which had a lower baseline probability than eating. Contingent eating clearly facilitated three of the instrumental responses, but not the other three. In addition to their contradiction of Equation 1, the results appeared to contradict the view that deprivation of the contingent response is a sufficient antecedent condition for facilitation of the instrumental response, and that the amount of response deprivation is a reliable predictor of the amount of facilitation (Timberlake and Allison, 1974). More generally, Shettleworth's results would contradict any theory whose predictions depend only on the baselines and the schedule requirements (e.g., Mazur, 1975), and indicate the need for a theory that can take into account not only the baselines and the schedule requirements, but also the character of each response in relation to the other (e.g., Allison, 1976). This general conclusion is also supported by a recent experiment in which thirsty rats were presented with a lever and a water spout under two experimental conditions: one in which the lever could be depressed by a relatively light touch, and one that required a much heavier touch (Allison, Miller, and Wozny, in press). Neither the baselines nor the schedule requirements would have led one to expect any difference in contingency between the light-touch condition and the heavy, but the results showed more lever pressing in the light than in the heavy (see also Logan, 1964).

Shettleworth's experiment suggests that it is not a sufficient condition for facilitation of the instrumental response that the contingent response have the higher baseline probability. Other experiments suggest that the condition is also not necessary. In each of these other experiments, the contingency schedule deprived the individual of the contingent response, and succeeded in facilitating the instrumental response, despite the fact that the

contingent response had the lower baseline probability (Allison *et al., in press;* Allison and Timberlake, 1973, 1974; Eisenberger, Karpman, and Trattner, 1967; Klajner, 1975). Some of these references document another critical point, that the amount of facilitation depends on the schedule requirements. For example, Klajner (1975) showed that the amount of facilitation was an increasing function of the number of instrumental lever presses required for each contingent manipulation of a plunger. In contrast with other formulations (Allison, 1976; Mazur, 1975; Timberlake and Allison, 1974), Equation 1 makes no provision for this graded effect, because the equation makes no distinction among schedules that deprive the individual of the contingent response.

Other experiments have challenged the importance of the probability differential condition by showing that either of two responses can be made to facilitate the other if the schedule requirements are manipulated while nothing is done to alter the relative baseline probabilities. In two such experiments, rats ran in an activity wheel and drank saccharin (Timberlake and Allison, 1974) or sucrose solution (Mazur, 1975). Both experiments demonstrated that either response could be made to show a facilitation effect merely by manipulating the contingency schedule requirements. Mazur's experiment deserves special mention for the clarity of its demonstration that suppression, like facilitation, does not depend on the antecedent condition implied by Equation 1. Among four of his five rats there was at least one schedule that facilitated running (the low-probability response) and suppressed drinking (the high-probability response), in conformity with Equation 1, but at least one other schedule that suppressed running and facilitated drinking, contrary to Equation 1.

The evidence discussed above suggests that facilitation and suppression can occur independently of the relation between the baseline probabilities of the two responses. But even if its implications for facilitation and suppression are not accurate, Equation 1 might still provide an accurate guide to general effects of individual variables. Some examples can be provided through rearrangement of Equation 1, which leads to the following expression for the magnitude of the facilitation effect, $p'_N - p_N$:

$$p'_N - p_N = k(p_C - p_N). \qquad (2)$$

Equation 2 implies that the magnitude of the facilitation effect should increase with the baseline level of the contingent response, p_C. Available evidence supports that implication rather clearly (Timberlake and Allison, 1974, p. 157)—an implication shared by several other theoretical formulations, such as the response-deprivation analysis (Timberlake and Allison, 1974, p. 156) and the conservation model (Allison, 1976, Equation 14). Less clear is the empirical relation between the magnitude of the facilitation effect and the baseline level of the instrumental response, p_N. Equation 2 implies that the magnitude of the facilitation effect should increase as p_N decreases, and some experiments have demonstrated such a relation (Timberlake and Allison, 1974, p. 158). Other experiments have shown the opposite relation, but these have been marred by methodological problems that make interpretation difficult—problems related to the tendency to overshoot schedule requirements as a function of p_N (*cf.* Timberlake and Allison, 1974, p. 158; Bauermeister, 1975, p. 154).

Judging from published evidence, present standards seem to require at minimum a model that takes into account not only the baselines and the schedule requirements, but also the character of each response relative to the other. Additional research will surely refine the standards still further. One new requirement is already evident from a recent experiment that varied the behavior required in switching from either response to the other (Allison *et al., in press*). A retractable lever and a retractable water spout were positioned on the same wall about 8 cm apart. In one experimental condition, a windowed partition placed between lever and spout ensured that the rat's shortest route between lever and spout was about 48 cm long. In the other experimental condition, the partition was removed, which meant that the shortest route was only about 8 cm long. Baseline measurements, which revealed no difference between the two conditions in terms of total drinking, total pressing, and the number of times the individual switched from pressing to drinking or from drinking to pressing, were followed by contingency training on three different schedules. As predicted by the conservation model (Allison, 1976, Equation 11), some schedules

produced more switching than others, but other features of the results were not anticipated by the model. Specifically, schedules that produced a relatively large amount of switching also produced considerably less pressing and drinking in the long-trip condition than in the short-trip condition. This difference was significantly diminished on schedules that produced relatively little switching. These results have led to a revised version of the conservation model, which incorporates not only the baselines, the schedule requirements, and the character of each response in relation to the other, but also the behavior required in simply switching from either response to the other (Allison et al., in press).

REFERENCES

Allison, J. Contrast, induction, facilitation, suppression, and conservation. Journal of the Experimental Analysis of Behavior, 1976, 25, 185-198.

Allison, J., Miller, M., and Wozny, M. Conservation in behavior. Journal of Experimental Psychology: General, (in press).

Allison, J. and Timberlake, W. Instrumental and contingent saccharin-licking in rats: response deprivation and reinforcement. Bulletin of the Psychonomic Society, 1973, 2, 141-143.

Allison, J. and Timberlake, W. Instrumental and contingent saccharin licking in rats: response deprivation and reinforcement. Learning and Motivation, 1974, 5, 231-247.

Bauermeister, J. J. Asymptotic reinforced responding as a function of the operant level of the instrumental response. Learning and Motivation, 1975, 6, 143-155.

Donahoe, J. W. Some implications of a relational principle of reinforcement. Journal of the Experimental Analysis of Behavior, 1977, 27, 341-350.

Eisenberger, R., Karpman, M., and Trattner, J. What is the necessary and sufficient condition for reinforcement in the contingency situation? Journal of Experimental Psychology, 1967, 74, 342-350.

Klajner, F. The relations among instrumental performance, reinforcement, and contingent-response deprivation in the instrumental conditioning paradigm. Unpublished doctoral dissertation, University of Toronto, 1975.

Logan, F. A. The free behavior situation. In D. Levine (Ed), Nebraska symposium on motivation, 1964. Lincoln: University of Nebraska Press, 1964. Pp. 99-128.

Mazur, J. E. The matching law and qualifications related to Premack's principle. Journal of Experimental Psychology: Animal Behavior Processes, 1975, 4, 374-386.

Premack, D. Reinforcement theory. In D. Levine (Ed), Nebraska symposium on motivation, 1965. Lincoln: University of Nebraska Press, 1965. Pp. 123-190.

Shettleworth, S. J. Reinforcement and the organization of behavior in golden hamsters: hunger, environment, and food reinforcement. Journal of Experimental Psychology: Animal Behavior Processes, 1975, 1, 56-87.

Timberlake, W. and Allison, J. Response deprivation: an empirical approach to instrumental performance. Psychological Review, 1974, 81, 146-164.